PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 20 November 2000 (20.11.00)	
International application No. PCT/SE00/00591	**Applicant's or agent's file reference** 99702 TP
International filing date (day/month/year) 27 March 2000 (27.03.00)	**Priority date** (day/month/year) 26 March 1999 (26.03.99)
Applicant NILSON, Thord, Agne, Gustaf	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

25 October 2000 (25.10.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer F. Baechler
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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.
PCT/SE 00/00591

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5448123 A	05/09/95	DE 69303666 D,T	06/03/97
		EP 0571347 A,B	24/11/93
		SE 500596 C	18/07/94
		SE 9201406 A	06/11/93
US 5864196 A	26/01/99	CN 2270309 U	10/12/97
		DE 29613477 U	24/10/96

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference --	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/SE00/00591	International filing date *(day/month/year)* 27.03.2000	Priority date *(day/month/year)* 26.03.1999
International Patent Classification (IPC) or national classification and IPC7 H 02 K 1/27		
Applicant Atlas Copco Controls AB et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
25.10.2000	24.04.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Authorized officer Håkan Sandh/MN Telephone No. 08-782 25 00

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE00/00591

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the drawings:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE00/00591

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-8	YES
	Claims		NO
Inventive step (IS)	Claims	1-8	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-8	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The invention relates to a rotor for a high-speed permanent magnet motor. The rotor comprises a plurality of stacked magnetic discs. According to the invention, reinforcement discs are arranged between the magnetic discs to accomplish a frictional engagement between the magnetic discs and the reinforcement discs for transferring centrifugal forces from the magnetic discs to the reinforcement discs.

Documents cited in the International Search Report:

D1=RU 2074478
D2=SU 1835112
D3=US 5448123
D4=US 5864196

The cited documents D1-D3 all relates to electric machines having permanent magnet rotors. Document D4 relates to an electric machine having a rotor laminated with non-magnetic plates. However, none of the documents discloses a high-speed rotor as defined in the claims and there is no teaching in the prior art that would lead a skilled person to the invention. Therefore, the claimed invention is not considered to be obvious.

Accordingly, the claimed invention is novel and considered to involve an inventive step.
The invention is industrially applicable.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/00591

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H02K 1/27
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent's abstract, No 97-433729/40, week 9740, ABSTRACT OF RU, 2074478 (LOTOTSKII V L), 27 February 1997 (27.02.97) --	1-8
A	Derwent's abstract, No 95- 73784/10, week 9510, ABSTRACT OF SU, 1835112 (MAGNETON RES PRODN ASSOC), 15 August 1993 (15.08.93) --	1-8
A	US 5448123 A (THORD A. G. NILSON ET AL), 5 Sept 1995 (05.09.95), abstract --	1-8
A	US 5864196 A (JA DONG YUN), 26 January 1999 (26.01.99), column 1, line 25 - line 39 --	1-8

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 July 2000	24 -07- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer HÅKAN SANDH/EE Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

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International application No.
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US 5864196 A	26/01/99	CN 2270309 U	10/12/97
		DE 29613477 U	24/10/96

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PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification** 7 : H02K 1/27

A1

(11) **International Publication Number:** **WO 00/59097**

(43) **International Publication Date:** 5 October 2000 (05.10.00)

(21) **International Application Number:** PCT/SE00/00591

(22) **International Filing Date:** 27 March 2000 (27.03.00)

(30) **Priority Data:**
9901107–4 26 March 1999 (26.03.99) SE

(71) **Applicant** *(for all designated States except US)*: ATLAS COPCO CONTROLS AB [SE/SE]; Solkraftsvägen 13, S–135 70 Stockholm (SE).

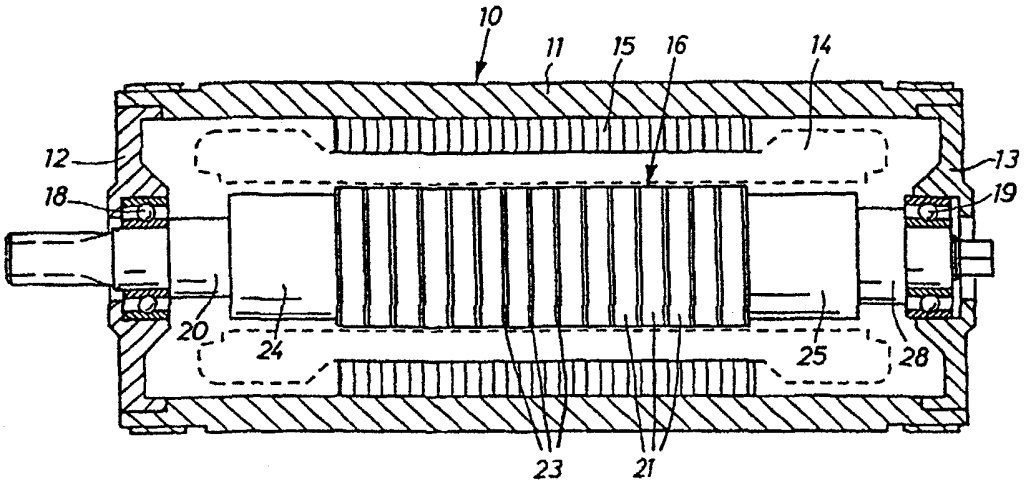
(72) **Inventor; and**
(75) **Inventor/Applicant** *(for US only)*: NILSON, Thord, Agne, Gustaf [SE/SE]; Långsjövägen 2B, S–135 54 Tyresö (SE).

(74) **Agent:** PANTZAR, Tord; Atlas Copco Tools AB, S–105 23 Stockholm (SE).

(81) **Designated States:** US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) **Title:** ROTOR FOR A HIGH SPEED PERMANENT MAGNET MOTOR



(57) **Abstract**

A rotor for a high speed permanent magnet motor comprises a central spindle (20), a plurality of magnet discs (21) stacked on the spindle (20) and axially clamped by a clamping device (24–26, 28) on the spindle (20) to form an axially pre–tensioned disc packet core (16), each magnet disc (21) has at least one electrically insulating layer, wherein between the magnet discs (21) and/or between one magnet disc (21) and the clamping device (24–26, 28) there are located a reinforcement discs (23) of a high–strength material, and the reinforcement discs (23) are clamped between the magnetic discs (21) or between one magnet disc (21) and the clamping device (24–26, 28) such that a clamping force generated frictional engagement is obtained between the reinforcement discs (23) and the magnet discs (21) by which centrifugal forces are transferred from the magnet discs (21) to the reinforcement discs (23) during motor operation, thereby relieving the magnet discs (21) of tensile stress.

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EE	Estonia	**LR**	Liberia	**SG**	Singapore		

Rotor for a high speed permanent magnet motor.

The invention relates to a rotor for a high speed permanent magnet motor. In particular, the invention concerns a motor rotor comprising a plurality of magnetic discs stacked on a central spindle, a clamping device provided to exert an axial clamping force on said magnetic discs to form an axially pre-tensioned disc packet, wherein each of said magnetic discs is provided with at least one electrically insulating layer for electrical separation relative to adjacent discs or to said clamping device.

It is a fact that permanent magnetic materials used in motor rotors are exposed to a high centrifugal stress, and that the tension strength limit of such materials is easily reached at high speed operation. This means that permanent magnetic rotors have to be reinforced to cope with the high centrifugal stresses generated at high speed operation.

A previously known method to reinforce permanent magnet rotors is to provide an outer sleeve enclosing the permanent magnetic material parts of the rotor. Such sleeve may comprise a high-strength metal tube made of on non-magnetic material like titan, cold worked stainless steel etc. or may be formed of a high-strength fiber bandage wound around the permanent magnet parts of the rotor. In both cases the reinforcement is radially pre-tensioned to minimize the tension stress on the magnetic material caused by centrifugal forces during operation of the motor.

In small diameter rotor applications, an outer reinforcement sleeve is undesirable since it adds to the diameter of the rotor. It is undesirable also from the manufacturing cost point of view, because the sleeve not only adds one or more details to the rotor, it also adds a

number of extra working operations when assembling the rotor.

The above mentioned problems are solved by the invention since a permanent magnet rotor according to the invention does not involve any outer sleeve, but comprises a reinforcement means which does not influence on the diameter of the rotor and does not complicate the assemblage of the rotor.

A preferred embodiment of the invention is below described in detail with reference to the accompanying drawing.

On the drawing:
Fig. 1 shows, partly i section, a side view of a motor having a rotor according to the invention.
Fig. 2 shows a longitudinal section through a rotor according to the invention.
Fig. 3 shows, on a larger scale, a fractional view of the rotor in Fig. 2 illustrating schematically the magnet disc arrangement according to the invention.

The motor illustrated in the drawing figures comprises stator 10 including a cylindrical casing 11, two end walls 12,13, electrical windings 14 and a tubular core 15 surrounding the windings 14, and a rotor 16. The rotor 16 is journalled in two bearings 18,19 supported in the stator end walls 12,13 and comprises a central spindle 20, a plurality of permanent magnet discs 21 provided on each side with a layer 22 of electrically insulating material, and a number of reinforcement discs 23 located between the magnet discs 21. The purpose and functional features of the reinforcement discs 23 will be described in further detail below.

The insulating layers 22 provided on the magnet discs 21 consists suitably of an inorganic material, for instance an oxidized aluminium foil. This type of material has a very high coefficient of elasticity, which means that it has practically no tendency to creep under heavy centrifugal loads. Neither have these materials any tendencies to adopt different coefficients of elasticity at different temperatures. This is advantageous when operating a motor at a very high speed under shifting load conditions.

Since the magnet material used for this purpose is quite brittle and, accordingly, has a low tensile strength, the packet of discs 21 is axially pre-tensioned to assure that no tensile stress in the magnet discs 21 in the axial direction will occur during operation of the motor. This is accomplished by a clamping device comprising two sleeve elements 24,25 mounted on the spindle 20. One of these sleeve elements 24 is axially supported against a shoulder 26 on the spindle 20, whereas the other sleeve element 25 is backed by a nut 28 engaging a thread 29 on the spindle 20. At the assembly of the rotor 16, the nut 28 is tightened up to the yield stress level of the spindle material in order to obtain the highest possible pre-tension of the magnet disc packet and to assure that no local tension stresses due to bending loads on the rotor 16 will occur in the magnet disc packet.

A permanent magnet motor of the above type is previously described in US Patent No. 5,448,123.

In this type of motor, the magnet discs 21 are also exposed to heavy centrifugal forces during high speed operation, which means that the magnet material may be exposed to a detrimental tensile stress. This, however, is avoided by inserting on both side of each magnet disc 21 a reinforcement disc 23 which due to the axial clamping

action accomplished by the clamping device 24-26,28 frictionally engages each side of the magnet discs 21. This frictional engagement results in a transfer of centrifugal forces from the magnet discs 21 to the reinforcement discs 23 resulting in a tensile stress relief in the magnet discs 21.

In order to fulfil this task, the reinforcement discs 23 are made of a high-strength material such as high-strength metal, ceramic, composite etc. which is very stiff to tensile forces. Accordingly, the coefficient of elasticity of these materials is very high.

In some cases, where the centrifugal forces are not too high and/or the magnet discs 21 are thin, it might be enough to use a reinforcement disc 23 between every second magnetic disc 21 only.

If the magnet discs 21 are thin, it may also be enough to use an electrically insulating layer 22 between every second magnet disc 21 only.

As appears from the drawing figures, the magnetic discs 21 as well as the reinforcement discs 23 are of a flat shape and the centrifugal forces appearing in the magnetic discs 21 are transferred by pure friction to the reinforcement. Using pure flat discs is advantageous in that the discs are easily manufactured from sheet material. Machining the discs into other shapes would be very difficult since the high-strength material in the reinforcement discs 23 is very hard to work. It is conceivable, though, to use conical discs such that the frictional engagement between the magnetic discs 21 and the reinforcement discs 23 is amplified by a radial wedge action between the discs.

In order to accomplish a radial pre-tensioning of the magnetic discs 21 and ensure that absolutely no tensile forces would occur in the magnetic material, the reinforcement discs 23 are heated up before assembling and axially clamping the rotor disc packet. If, however, the thermal coefficient of expansion for the reinforcement discs is sufficiently higher than that of the magnetic discs, it is sufficient to heat the complete rotor assembly before axially clamping the disc packet. Heating of the complete rotor assembly would of course simplify the assembly process. When cooling off, the shrinkage of the reinforcement discs 23 accomplishes, via the frictional engagement, a radially inwardly directed pre-tension of the magnet discs 21.

Claims.

1. Rotor for a high speed permanent magnet motor comprising a central spindle (20), a plurality of magnet discs (21) stacked on said spindle (20), said spindle (20) having a clamping device (24-26,28) for exerting an axial clamping force on said magnet discs (21), thereby forming an axially pre-tensioned disc packet,
c h a r a c t e r i z e d in that between at least every second magnet disc (21) and /or between one magnet disc (21) and said clamping device (24-26,28) there is located a reinforcement disc (23) of a non-magnetic high-strength material,
each reinforcement disc (23) being clamped by said axial clamping force between said at least every second magnet disc (21) or between one magnet disc (21) and said clamping device (24,26,28), thereby accomplishing a frictional engagement between said reinforcement discs (23) and said magnet discs (21) for transferring centrifugal forces from said magnet discs (21) to said reinforcement discs (23), thereby relieving said magnet discs (21) of tensile stress.

2. Rotor according to claim 1, wherein a reinforcement disc (23) is located between every two adjacent magnet discs (21).

3. Rotor according to claim 1 or 2, wherein each one of said magnet discs (21) comprises at least one electrically insulating layer (22).

4. Rotor according to claim 1, wherein said reinforcement discs (23) are flat in shape.

5. Rotor according to claim 1, wherein said reinforcement discs (23) consists of a high-strength metal.

6. Rotor according to claim 1, wherein said reinforcement discs (23) consists of a ceramic material.

7. Rotor according to claim 1, wherein said magnet discs (21) are radially pre-tensioned by a pre-assembly heat treatment of said reinforcement discs (23).

8. Rotor according to claim 7, wherein the thermal coefficient of expansion for the material of the reinforcement discs (23) is higher than that of the material of the magnet discs (21), and said heat treatment comprises a heating-up of the complete rotor assembly before applying said axial clamping force.

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5448123 A	05/09/95	DE 69303666 D,T	06/03/97
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A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H02K 1/27
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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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Date of the actual completion of the international search	Date of mailing of the international search report
18 July 2000	24 -07- 2000
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*LOTO/ V06 97-433729/40 *RU 2074478-C1

Rotor for magneto-electric machine - has ring permanent magnets enveloped on the outside by rings made from highly strong material in particular from titanium alloy

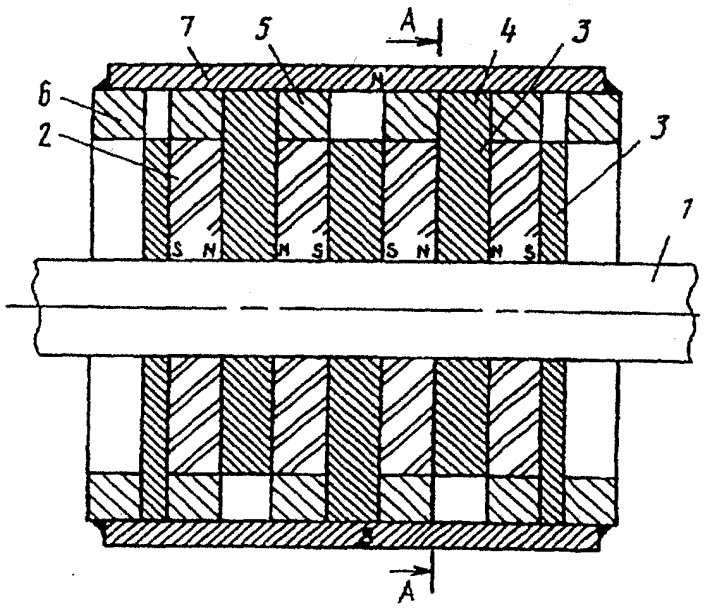
LOTOTSKII V L 94.12.16 94RU-044243

X11 (97.02.27) H02K 1/27, 21/14

The rotor has non-magnetic shaft (1), raw of ring permanent magnets (2) axially magnetised and with alternating polarity, soft magnetic elements (3) having radial polar protrusions (4) with close-fitting to butt surfaces of permanent magnets (2) with angular shift by one pole pitch, rings (5) made from highly strong non-magnetic material enveloping magnets (2), also rings (6) in butt parts of rotor. The pole shoes (7) are fastened to ring (5,6) and to polar protrusions (4) by welding.

The rotor is characterised by a monocytic construction and a high mechanical strength. This ensures its utilisation in high speed magneto-electric machines.

USE/ADVANTAGE - In construction of rotor for high-speed electrical machines with raised mechanical strength of rotor. (3pp Dwg.No.1/2)



★MAGN= V06 95-073784/10 ★SU 1835112-A3

Rotor of end-type gated electric motor - has inductor formed by 2 permanent magnets with alternating directions of magnetisation and uses ring of magnetically-soft material to separate permanent magnets

MAGNETON RES PRODN ASSOC 91.06.14 91SU-4953146

X11 (93.08.15) H02K 1/27

The rotor of an end-type rectifier electric motor contains an inductor with a shaft (4) and the inductor is made of 2 multi-pole axially magnetised rings of solid or sectioned permanent magnets (1,2) with alternating directions of magnetisation and with identical outer and inner dias. and with a height according to the degree of magnetisation. A ring (3) of magnetically-soft material is firmly fixed between the similar poles of the permanent magnets and has calculated outer and inner dia.

The outer and inner dias. of the ring (3) are calculated using the residual inductance of the permanent magnets (1,2), the satn. inductance of the magnetically-soft ring (3) and the number of poles of the circular permanent magnets (1,2).

USE/ADVANTAGE - Construction of electric motors with gate-commutation. Reduced specific use of material of permanent magnets of inductor. Bul.30/15.8.93 (3pp Dwg.No.1/4)

N95-053482 **V06-M07B**